Contribution to the early life history of killifishes in Ontario

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ABSTRACT

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Age 0 blackstripe topminnow *Fundulus notatus* and western banded killifish *Fundulus diaphanus menona* are described and illustrated. The blackstripe topminnow has a body-length lateral black stripe, an articulated snout, rounded caudal fin, and modal values of 10 anal, 8 dorsal, 15 pectoral and caudal fin rays, 16 pre- and postanal myomeres, 33-35 mid-lateral scales and 32-34 vertebrae. The western banded killifish has unique ventral pigmentation during early development identifies small larvae. Yolk is absorbed at 8 or 9 mm, pelvic buds appear at 10-11 mm and scales at 12-14 mm. The origin of the dorsal fin precedes the anal fin in mid-body. Scalation is complete at ~20 mm, when lateral pigment is first expressed as distinct vertical bands. Modal fin ray counts are as follows: anal 9, dorsal 10, pectoral and caudal 13 and 16, respectively. There are 15 preanal and 17 postanal myomeres, and 34-35 vertebrae.

RÉSUMÉ

Leslie, J.K., and C.A. Timmins. 2000. Contribution to the early life history of killifishes in Ontario. Can. Tech. Rep. Fish. Aquat. Sci. 2305.

Le présent article décrit des représentants d'âge 0 du fondule rayé (*Fundulus notatus*) et de la sous-espèce de l'Ouest du fondule barré (*Fundulus diaphanus menona*). Le fondule rayé possède une bande noire latérale sur toute la longueur, un museau articule et une nageoire caudale arrondie. Les valeurs modales observées chez cette espèce sont : 10 rayons sur la nageoire anale, 8 rayons sur la nageoire dorsale, 15 rayons sur les nageoires pectorales et caudale, 16 myomères pré- et post-anaux, 33-35 écailles situées au milieu de la ligne latérale, et 32-34 vertèbres. Une pigmentation particulière sur le ventre au début de la croissance caractérise la larve de la sous-espèce de l'Ouest du fondule barré. À 8-9 mm de longueur, le vitellus est entièrement résorbé. Les papilles pelviennes se forment lorsque le poisson mesure 10-11 mm, et les écailles apparaissent quand il atteint 12-14 mm. L'origine de la nageoire dorsale est antérieure à l'aplomb de la nageoire anale au milieu du corps. L'écaillure est complète quand le poisson atteint environ ~20 mm, longueur à laquelle les pigments latéraux apparaissent sous forme de bandes verticales bien distinctes. Le nombre modal des rayons est de 9 pour la nageoire anale, 10 pour la dorsale, 13 pour les pectorales et 16 pour la caudale. On observe aussi 15 myomères pré-anaux et 17 myomères post-anaux, ainsi que 34-35 vertèbres.

INTRODUCTION

The blackstripe topminnow *Fundulus notatus* (Rafinesque) is one of 19 "vulnerable" fishes in Ontario (Campbell 1998). Formerly considered an exotic species (Crossman 1984), it was recently classified as "native" (Mandrak and Crossman 1992). Appropriately, McAllister (1987) suggested that this fish should be classified "rare". Owing chiefly to rarity, constricted distribution, and lack of exploitable value to humans, it has received low priority in matters of ecological research. The blackstripe topminnow and the banded killifish *Fundulus diaphanus* are two of only three cyprinodontid (killifish) species in Canada. The mummichog *F. heteroclistis* occurs in saline waters of the Maritime Provinces, Gulf of St. Lawrence, and south-western Newfoundland (Gilhen 1974). The blackstripe topminnow was first collected in 1972 (Gruchy et al. 1973) in two locations in south-western Ontario, where it tolerates turbid conditions in low or base gradient streams with submersed terrestrial vegetation (McAllister and Gruchy 1977). This fish may be a recent immigrant from adjacent watersheds in the United States, or a relict (Trautman 1981) overlooked in field surveys in Ontario. Carranga and Winn (1954) described the reproductive behaviour of the blackstripe topminnow, and Trautman (1981) provided identifying characteristics and illustrated adult fish. However, considerable gaps remain in its taxonomy, especially in respect of early life history.

In contrast to the blackstripe topminnow's limited distribution, the banded killifish inhabits many bodies of water, especially protected shallow areas where sparse growths of rushes prevail. The North American geographic range extends from the northern limit in Canada throughout the central and mid-western states to the Gulf of Mexico (Hubbs and Lagler 1964). It often occurs in dense schools at the surface, searching for insects and other food items. Of two subspecies of *Fundulus diaphanus* known in Ontario, *F. d. menona* (western) and *F. d. diaphanus* (eastern), the former is most prevalent and widespread in central and western areas of the province, whereas the latter is found mainly in the south-east (Mandrak and Crossman 1992). Fish (1932) briefly described early developmental stages of *Fundulus diaphanus menona* collected near Crescent Beach, Lake Erie, and Jones and Tabery (1980) described larvae of *F. d. diaphanus* from the estuary of the Hudson River.

Generally, taxonomists tend to postpone descriptions of early life stages of fishes until a complete size range or growth sequence is available. For logistic reasons alone, collection of

field specimens fulfilling this criterion is rarely possible; hence, the rarity of descriptive works on "wild" fish larvae of the Great Lakes. Because taxonomy is a necessary tool in support of biodiversity inventories, partial descriptions are better than none. Therefore, we describe and illustrate 'early' juvenile (age 0) stages of the blackstripe topminnow, collected sporadically during the past 15 yr. Despite sampling on at least 30 dates, we failed miserably in efforts to find earliest developmental stages of this taxon.

Age 0 eastern banded killifish and western banded killifish are very similar in morphology and colour, and have been described, sometimes together, as *Fundulus diaphanus* (see Jude 1982). Thus, although meristics differ slightly between the two subspecies, there is little doubt as to the identification of age 0 "*Fundulus diaphanus*". Herein, age 0 western banded killifish and blackstripe topminnow in the same size category are compared in relation to morphologic, meristic, and pigmentary characteristics. In this report, we provide descriptions and illustrations of these fish (including larvae of the western subspecies) and comment briefly on their autecology.

Study area (blackstripe topminnow)

The St. Clair flatlands are expansive and featureless, cultivated intensively for cash crops (grains, vegetables), and intersected by numerous drainage ditches and small streams in the Sydenham River watershed and vicinity. Many of these water systems are connected, but all are ultimately tributary to Lake St. Clair or the St. Clair River. Soils of the flatlands consist mainly of sandy loam overlying clay. Drainage from cropland creates high turbidity in ditches and streams, resulting in progressive deposits of enriched, polluted sediment before discharging into larger systems (Leslie and Timmins 1990).

Most sampling for blackstripe topminnows took place in Whitebread agricultural drainage ditch, near Wallaceburg, Lambton County (42° 36' 00" N; 82° 23' 00" W). Additional collections were made at two sites in Black Creek (42° 36' 09" N; 82° 10' 16" W), and at 10 sites within a 15-km stretch in Little Bear Creek (42° 30' 54" N; 82° 14' 30" W). These streams are tributary to the Sydenham River, Kent County (Fig. 1). Although sampled on only two dates, Black Creek and Little Bear Creek yielded a higher total number of fish (67) than did Whitebread ditch over the course of several years (N = 41 fish).

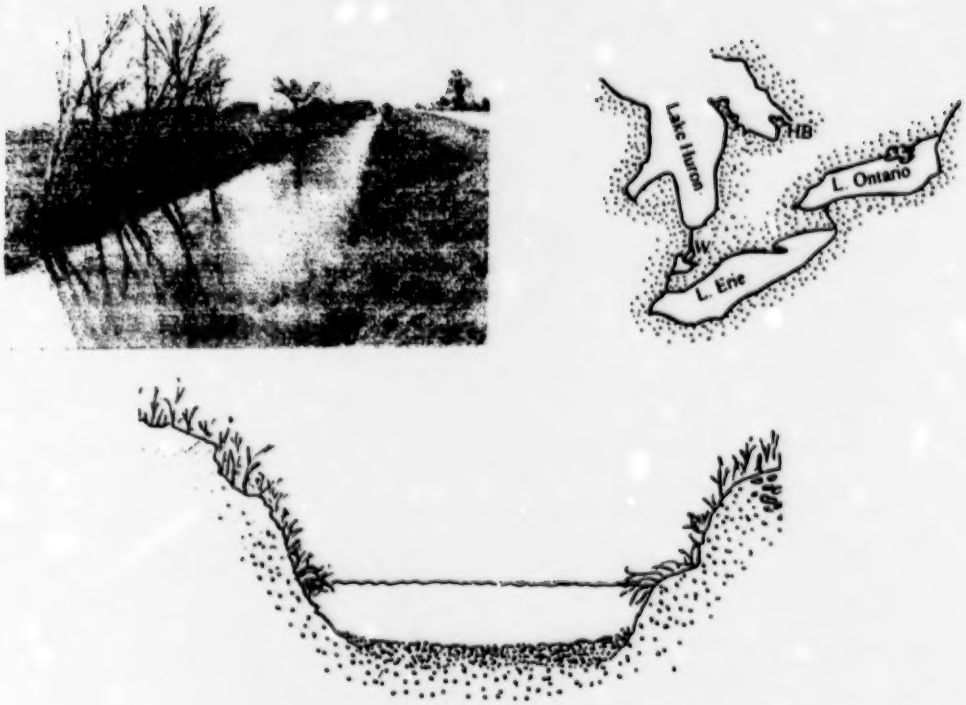

Fig. 1. Collection sites in south-western (W = Whitebread ditch) and south-central (HB = Hog Bay) Ontario for blackstripe topminnow and western banded killifish, respectively. Photo (by C.A. Timmins) shows Whitebread ditch, Lambton County. Sketch depicts slumping banks, terrestrial vegetation and substrate.

Whitebread ditch is about 8 km long, and drains cropland near the St. Clair River delta. The substrate is typically grey-brown clay overlain with amorphous detrital material. Water varies in colour from grey to yellow-brown and pale green, depending on season. During April to November, Secchi disc transparency ranged from 8 to 20 cm (Leslie and Timmins 1998). Water clarity occasionally allows visibility to the bottom in late November or December. Ice typically covers the ditch from January to March. As hydrologic connectivity with the St. Clair River is weak, stagnation occurs in mid-summer, especially in drainage ditch "dead-ends". Whitebread ditch is bowl-shaped, 19 m wide at its brim, and ~1.5 m deep in mid-summer.

Although there is no rooted aquatic vegetation at the collection site, terrestrial grasses grow at the waterline of slumping banks (Fig.1). Such vegetation provides cover, if not spawning substrate, for the blackstripe topminnow. At least 34 fish species are known to co-occur in Whitebread ditch (Leslie and Timmins 1998).

Black Creek and Little Bear Creek are sluggish, turbid streams draining watershed in Kent and Lambton counties, and are tributary to the Sydenham River, which flows into Lake St.Clair. Collections of blackstripe topminnows were made in isolated pools during extremely low water level in the Great Lakes basin. In late September 1999, Black Creek water temperature was 22 C, conductivity measured 874 µS/cm, and Secchi disc transparency was 13 cm. Most sampling took place at a depth of ~20 cm.

In addition to blackstripe topminnow, species in Black Creek and Little Bear Creek were represented by green sunfish *Lepomis cyanellus*, northern pike *Esox lucius*, spottail shiner *Notropis hudsonius*, emerald shiner *Notropis atherinoides*, mimic shiner *Notropis volucellus*, bluntnose minnow *Pimephales notatus*, johnny darter *Etheostoma nigrum*, blackside darter *Percina maculata*, brown bullhead *Ameiurus nebulosus*, white crappie *Pomoxis annularis*, and bluegill *Lepomis macrochirus*. Aquatic vegetation was sparse and was represented primarily by water lily (*Nuphar* sp.) and patches of bulrush (*Scirpus* sp.). The bottom consisted mainly of clay, rubble, rocks, and leaves.

Study area (western banded killifish)

Age 0 western banded killifish were collected in Hog Bay, a small (320 ha) eutrophic bay on the south coast of Severn Sound. Hog Bay lies just south of the Precambrian Shield, and is severely impacted by human interference. It is nutrient loaded as a result of human activities, e.g., discharge and seepage from settlements, marinas, cottages, and effects of year-round recreational fishing and boating. Typically, water temperature remains above 15 C from mid-May to mid-September; conductivity averages 160 µS/cm, Secchi disc transparency is 2 m, and pH is 8.5 (Leslie and Timmins 1995). Rooted vegetation invests almost the total substrate in summer. Numerically dominant fishes collected at the shore in Hog Bay included yellow perch *Perca flavescens*, blackchin shiner *Notropis heterodon*, bluntnose minnow, largemouth bass *Micropterus salmoides*, and pumpkinseed *Lepomis gibbosus*. Banded killifish formed only 1%

of the total collection of age 0 fishes in 1992-93 (Leslie and Timmins 1994). Fish used in this study were found in sparse stands of spike rush *Eleocharis* spp., and in shaded areas at several boat ramps.

METHODS

In Whitebread ditch, most collections were made with a bulging larval fish beach seine (4-m long, 1-m wide, 0.3-mm mesh). Larger fish were caught with small mesh (3 and 6 mm opening) beach seines (3-m long, 1-m wide). Sampling took place every 1 to 3 wk from April to October 1986 and 1990. Whitebread ditch was subsequently sampled expressly for the blackstripe topminnow once or twice each year until 1997. In Black Creek and Little Bear Creek, collections took place once in late September and November 1999. Fish were 'fixed' on site with 5-10% formalin, then within 1 mo, preserved with Davidson's B solution. Most linear measurements of body parts and meristics were recorded 1-3 yr post-collection. A small number of specimens was cleared and stained according to methods described by Pottoff (1984); these fish were used for confirmation of numbers of myomeres and vertebrae.

Techniques used to determine morphometric and meristic characteristics for older age 0 fish generally follow those described in Hubbs and Lagler (1964), whereas early developmental stages follow methods in Leslie et al. (1986). Total count of caudal fin rays includes one unbranched ray adjacent to the first and last branched ray (Fig. 2). Dorsal and anal fin rays are counted according to the method described in Hubbs and Lagler (1964), whereby the first ray counted lies adjacent to the first branched ray that follows it, and the last ray counted includes the final, small ray next to the last branched ray. This protocol was retained for all specimens. Exact preanal myomere counts for *Fundulus* spp. are difficult to achieve because epaxial myotomes appear indefinite and pigment tends to obscure the anterior region of the body.

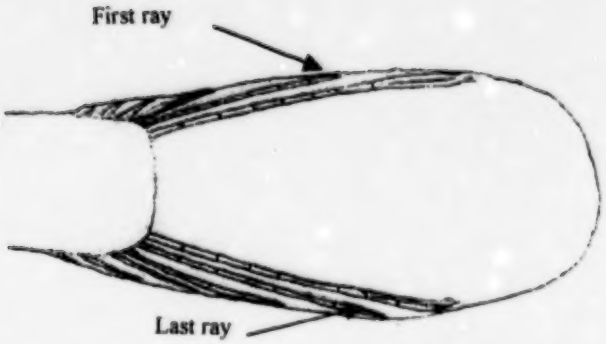

Fig. 2. Caudal fin ray count scheme for cyprinodontid fish, indicating first and last ray counted.

RESULTS

Fundulus notatus (Le Sueur)

Diagnosis

The blackstripe topminnow is a minnow-like fish (maximum TL <80 mm) with a terminal mouth, protracted premaxillaries, articulated snout, a robust body, and rounded caudal fin. The forehead and occiput are flat. Dorsal and anal fins are situated about mid-body, with anal fin originating slightly anterior to the origin of the dorsal fin. A prominent black mid-lateral stripe is a characteristic feature of this fish. Sexual dimorphism occurs whereby the shape of anal and dorsal fins and mid-lateral pigmentation patterns differ.

In Ontario, the blackstripe topminnow inhabits low gradient turbid streams with overhanging terrestrial grasses at their edge. Distribution of the species may be limited by the extent to which clear water influxes turbid waters (McAllister 1987). Indeed, in September 1999, numerous fish were collected in turbid conditions in Black Creek and Little Bear Creek, whereas no fish was found when water clarity improved in November 1999. In the present study, blackstripe topminnows ranged from 22 to 57 mm in total length (TL). Only one fish in our collection contained eggs. These eggs (N = 64), dark yellow and spherical (diameter = 1.2-1.7 mm), were removed from a 54-mm specimen collected in Whitebread ditch on June 1, 1988 when water temperature was 26.5 C and terrestrial grasses were established.

Morphology, morphometry, and meristics

The snout has a deep lateral groove, and while the mouth opening is horizontal, it is decidedly oblique at articulation. Both jaws have fine, comb-like teeth. The intestine is "S"-shaped. Large pores are located in an unpigmented area at the margin of the preopercle. The body lacks a lateral line. Scales occur on the side and top of the head, and between the pelvic fins. The tip of the depressed dorsal fin usually extends slightly posterior to the tip of the depressed anal fin. The tip of depressed pectoral fins extends almost to the pelvic fin base.

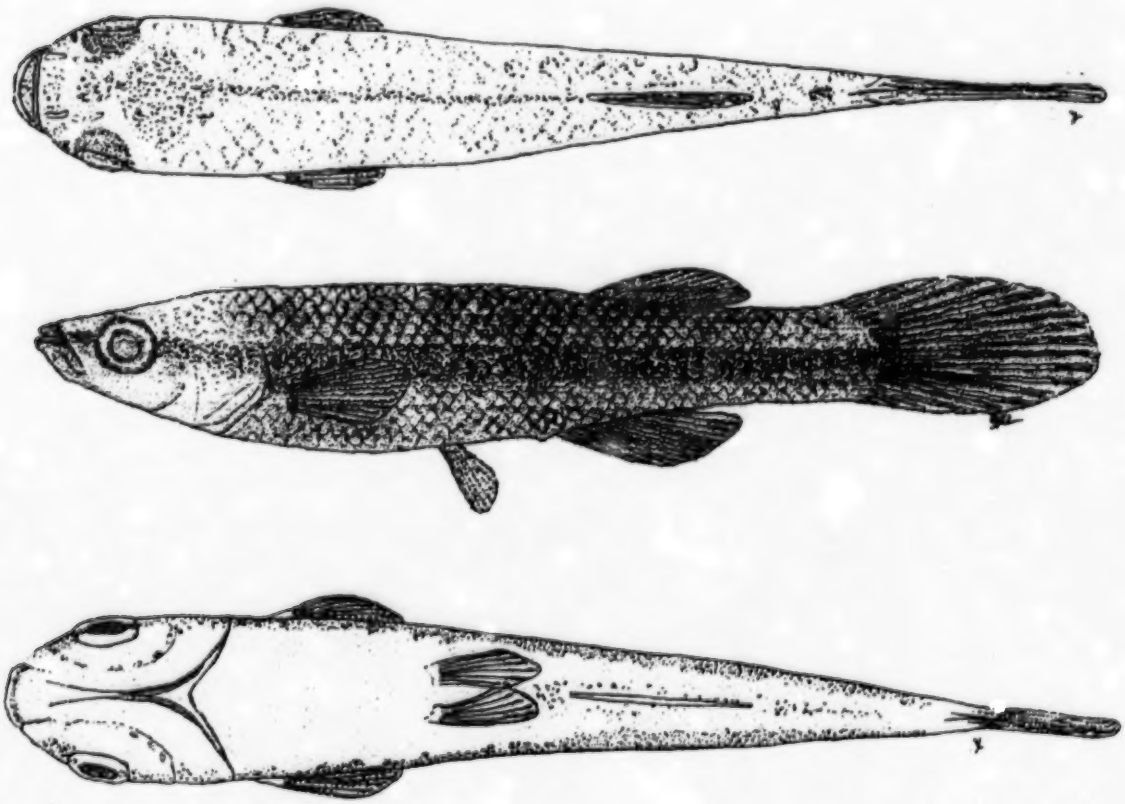

Fig. 3. Age 0 female blackstripe topminnow (22.0 mm) in dorsal (upper), lateral (middle) and ventral (lower) view.

Meristic data are given in Table 1, and comparative length data for age 0 fish in the 22-39 mm size class in Table 2. Mean standard length (±SD) averages 78.2 ± 1.0% TL, whilst eye diameter is 30.9 ± 1.5% of head length (range 28-33%). The pectoral fin length averages 14% TL. Eye diameter barely exceeds snout length. Snout length relative to head length (25-30%) is constant throughout the size class. Blackstripe topminnows have modal values of 10 anal, 8 dorsal, 15 pectoral, 6 pelvic, and 15 caudal fin rays. There are 17-20 anterior vertebrae (from head to origin of dorsal fin) and 32-34 total vertebrae. Further, we counted 15-17 preanal (modally 16) and 15-17 postanal myomeres (modally 16). A combination of at least three ratios listed in Table 2, together with reference to Fig. 3 and Fig. 4 should provide positive identification of the blackstripe topminnow.

Table 1. Mean and range of meristic characters for age 0 blackstripe topminnow (22-39 mm TL) collected in south-western Ontario. N = number of measurements.

MYOMERES	Preanal	Postanal	Total		
ξ	16.2	15.7	32.1		
Range	15-17	15-17	31-34		
N	42	42	42		
FIN RAYS	Dorsal	Anal	Pectoral	Pelvic	Caudal
ξ	7.9	9.8	15.2	6.0	14.7
Range	7-8	9-10	14-16	none	14-16
N	45	48	47	49	46

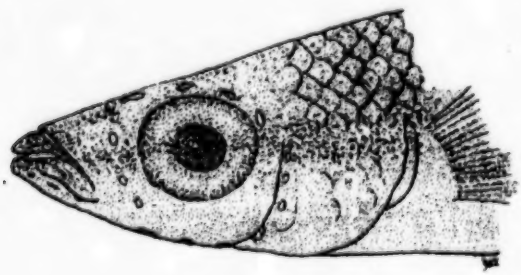

Fig.4. Lateral view of head of the blackstripe topminnow at 22 mm TL.

There are 20-23 scales on the dorsal mid-line from nape to dorsal fin origin, and 33-35 mid-lateral scales from the cleithrum to the base of the caudal fin, where at least 3 scales extend onto the fin base. Apart from different patterns of body-length stripe, separation of male and female age 0 blackstripe topminnows is based on the distance between the posterior margin of the depressed dorsal fin and origin of caudal fin relative to eye diameter. In male fish, this distance is 33%-50% eye diameter, whereas in females, eye diameter is equal to or greater than this distance. Length of the dorsal fin base is 87-92% of the anal fin base.

Pigmentation

A black stripe dominates the mid-lateral aspect of the fish. The stripe commences at the side of the lower jaw, extends to the eye (barely perceptible on small specimens), and continues to the base of the caudal fin (Fig 3). This stripe is more exaggerated on males, on whom vertical projections are evident. There are about 17-20 such projections on the largest fish in the size class studied. Margins of scales (cycloid) are outlined on the dorsum and lateral stripe. Most of the stripe lies ventro-laterally, especially posterior to the pelvic fins. On preserved fish, the ventro-lateral area exhibits a yellow to dull white appearance. Melanophores appear as minute, evenly spaced brown spots that cover the premaxillaries and chin (Fig. 4). Brown spots also appear in a small group at the side of the anus. There are small dots at the margins of pectoral rays, except on the 4 most ventral rays, which are usually barren.

Small specimens have few concentrated black spots on dorsal fin interradials, and largest fish have 3 or 4 large black blotches in mid-fin. Males have several blotches on the dorsal fin interradials, whereas females have serial dashes at the margin of fin rays. On some fish, a few small distal melanophores occur on longest posterior rays of the anal fins. A concentration of melanophores pronounces an indefinite spot on the caudal fin base (Fig. 3), and a series of small spots are evident on each side of fin rays. Pigmentation on pelvic fins is barely perceptible, especially on smallest fish.

Dorsally, a diamond-shaped patch is found on the occiput, followed by a thin line of pigment to the origin of the dorsal fin (Fig. 3). In small juveniles, this line is less conspicuous or absent between dorsal and caudal fins. Scale pattern on the dorsum is emphasised by pigment on

the posterior margin of each scale. Ventrally, the chin is faintly spotted; otherwise, the head is essentially barren, as are gut and intestine. Darker melanophores are evident at each side of the anus. Ventral pigment extends as a single, irregular line from the anal fin insertion to the caudal fin base (Fig. 3).

Table 2. Morphometric ratios for age 0 (juvenile) blackstripe topminnow *Fundulus notatus* (upper) and western banded killifish *F. diaphanus menona* (lower figures), in the 22-39 mm TL size class. Ratios based on mean of each body part.

	TOTAL (TL)	PRE-ANAL (PA)	PRE-DORSAL (PD)	PRE-PELVIC (PP)	>DEPTH (BD)	PEDUNCLE (PED)	HEAD (H)	EYE (E)
TL	X	**2.07** 2.02	**1.88** 2.03	**2.63** 2.55	**6.55** 5.73	**11.00** 11.45	**4.53** 4.07	**14.81** 14.00
PA	**0.48** 0.49	X	**0.91** 1.02	**1.27** 1.27	**3.17** 2.86	**5.32** 5.71	**2.19** 2.03	**7.16** 6.96
PD	**0.53** 0.49	**1.10** 0.98	X	**1.40** 1.22	**3.49** 2.75	**5.86** 5.53	**2.41** 2.00	**7.88** 6.78
PP	**0.38** 0.40	**0.79** 0.79	**0.71** 0.82	X	**2.49** 2.19	**4.18** 4.50	**1.72** 1.62	**5.63** 5.53
BD	**0.15** 0.17	**0.32** 0.35	**0.29** 0.36	**0.40** 0.46	X	**1.69** 2.00	**0.69** 0.72	**2.26** 2.40
PED	**0.09** 0.09	**0.19** 0.18	**0.17** 0.18	**0.24** 0.22	**0.60** 0.50	X	**0.41** 0.36	**1.35** 1.20
H	**0.22** 0.25	**0.46** 0.49	**0.41** 0.50	**0.58** 0.62	**1.45** 1.38	**2.43** 2.77	X	**3.27** 3.48
E	**0.07** 0.07	**0.14** 0.14	**0.13** 0.07	**0.18** 0.18	**0.44** 0.42	**0.74** 0.83	**0.31** 0.29	X

Fundulus diaphanus menona Jordan and Copeland

Diagnosis

The western banded killifish is a small (generally <100 mm) forage species with a moderately stout body and rounded caudal fin. The origin of the single dorsal fin precedes the origin of the anal fin. All fins are soft-rayed. The head is depressed dorsally, and premaxillaries

are protractile. This fish inhabits protected shallows in many bodies of water in the Great Lakes basin, but prefers sparse growths of rushes (Hubbs and Lagler 1964) such as those prevalent in the inner bay of Long Point (Lake Erie) and marshes of Lake St. Clair and Severn Sound (Lake Huron). Reproduction occurs in static water in late May to August. Fish (1932) described 7.1 and 12.3-mm stages of the western banded killifish collected in eastern Lake Erie. Biology of the banded killifish is detailed in Scott and Crossman (1973). With few obvious exceptions, morphology of the banded killifish and the blackstripe topminnow are very similar. In the blackstripe topminnow, the origin of the dorsal fin is anterior to the anal fin whereas these fins originate in the reverse order in the banded killifish. Further, the banded killifish has a lateral series of brown vertical bands, whilst the blackstripe topminnow has a body-length black stripe. Slight differences occur between western and eastern banded killifish with respect to meristics. The fish described in the present report is a subspecies of *F. diaphanus*, i.e., the western banded killifish *Fundulus diaphanus menona* Jordan & Copeland.

Morphology, morphometry, and meristics

Smallest fish in the 6.0-10.9 mm size class have remnant yolk, inflated single swim bladder, and flexed urostyle. The mouth is open and teeth are present on both jaws. The body is robust and large eyes dominate the flattened head. The body tapers gradually to the caudal peduncle, which is moderately deep. Dorsally, the fin fold originates at the 11^{th} or 12^{th} myomere and is continuous to the caudal fin. No trace of the fin fold was observed on fish >12.5-13.0 mm TL. Dark-yellow yolk, which contains spherical oil globules in ventro-lateral and ventral areas in the posterior of the yolk sac, is present in some 8-mm fish, but is usually absorbed at 8.5-9.0 mm. The lower jaw projects slightly anterior to the upper jaw at about 7 mm TL. In the 6-10.9 mm size class, few rays (4-6) are observed in dorsal, anal, and pectoral fins of smallest fish (Fig. 5). There are 10 articulated rays in the caudal fin at 7.0 mm. Pelvic fin buds first appear on fish as small as 9.8 mm and as large as 10.8 mm. Morphometric and meristic data are given in Table 3.

In the 11.0 to 15.9 mm size class, postorbital width is about 63% its length. The mouth opens horizontally, although its posterior margin appears oblique. The jaws articulate just anterior to the orbit (Fig. 5). Numbers of myomeres in fish >11 mm are less variable than for smaller fish (Table 3). For fish >11 mm, mean number of preanal and postanal myomeres are

14-15 and 17-18, respectively. At 11 mm, the ventral fin fold is continuous between the anus and the caudal fin. At 13.0 mm, the pectoral fin is 1.8 to 2.0 mm long, whereas the pelvic fin is a mere bud. The "flap" on the snout becomes more pronounced with growth.

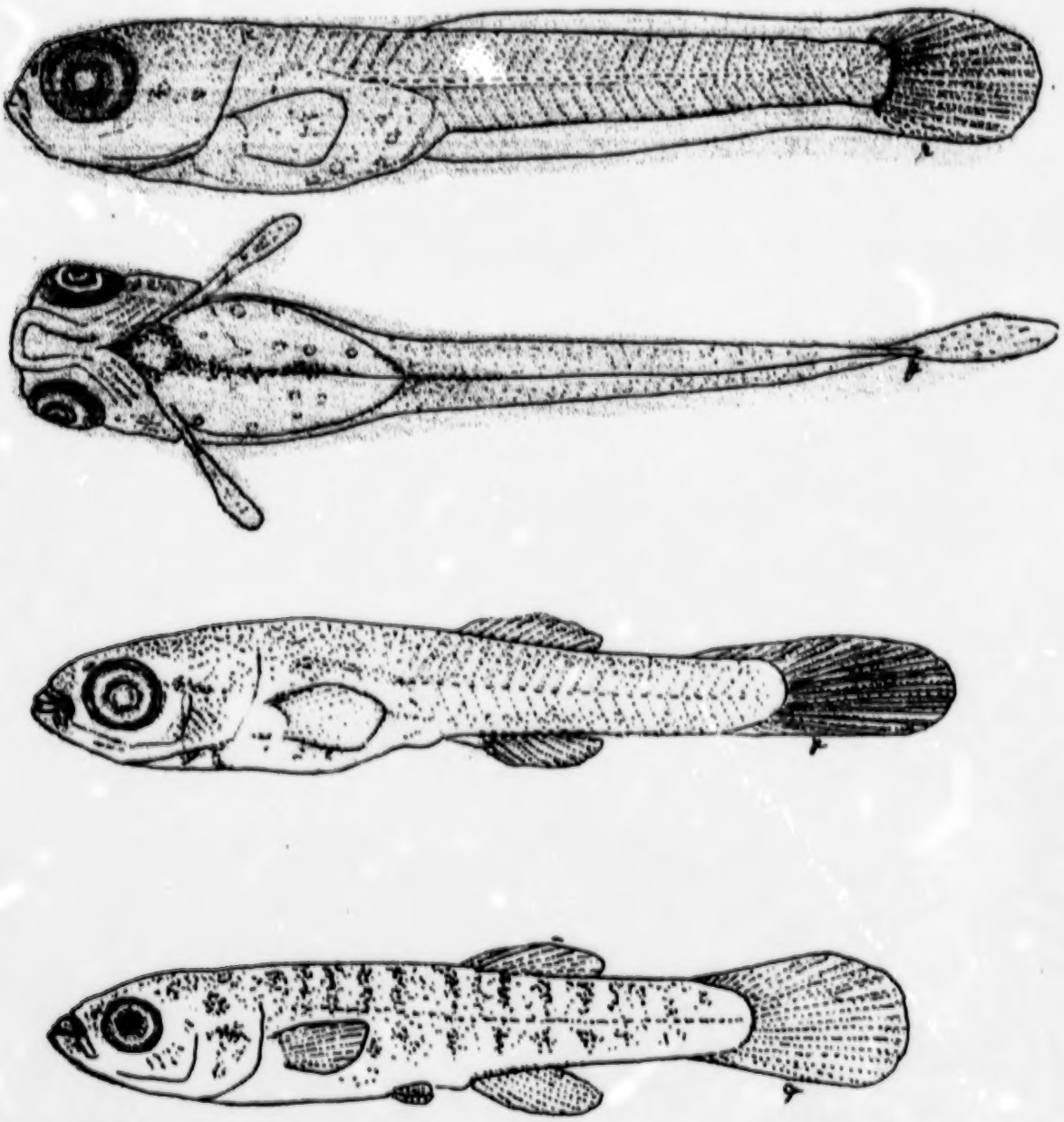

Fig. 5. Lateral and ventral view of western banded killifish at 6.5 mm (upper), lateral view at 12 mm (middle) and 20 mm (lower).

Table 3. Morphometric values (mean ± SD) expressed as percent of total length, with range (in parentheses) for age 0 *Fundulus diaphanus menona*. N = number of specimens measured.

	Total length size class		
	6.0 - 10.9 mm (N = 17)	11.0 - 15.9 mm (N = 23)	16.0 - 21.9 mm (N = 19)
TL (± SD)	8.0 1.6 (6.4-10.8)	13.9 1.6 (11.1-15.9)	18.6 1.6 (16.1-21.1)
Standard	84.4 1.6 (81-86)	83.4 1.7 (80-86)	82.3 1.7 (79-84)
Preanal	42.1 2.8 (39-46)	47.8 2.7 (41-52)	48.1 1.9 (43-50)
Predorsal	47 (N = 3) (44-50)	48.1 1.4 (43-51)	48.9 1.6 (46-51)
Prepelvic		41.0 1.4 (40-44)	40.4 1.7 (38-43)
Head	23.3 1.5 (20-25)	25.2 1.2 (23-27)	25.0 1.5 (23-28)
Eye	9.3 1.1 (8-11)	8.0 0.4 (8-10)	8.1 0.7 (7-9)
Body depth	15.7 1.9 (13-19)	16.3 0.8 (14-17)	16.6 1.0 (15-18)
Least peduncle	6.3 0.7 (6-8)	8.6 0.9 (6-10)	8.4 1.3 (6-10)

At all sizes of fish studied, eye diameter and head length relative to total length is more or less stable (Table 3). As fish grow, postorbital width in small fish (~7 mm) decreases from 80% to 63% at >10 mm, as does snout length relative to eye diameter. The intestine is "S"-shaped at 10-14 mm. Scalation exists along the mid-lateral body at 14-16 mm, and is complete at about 20 mm. The single air bladder extends to the anus. There are 34-35 vertebrae. Complete meristic and morphometric data for the western banded killifish are given in Table 4.

Pigmentation

Head and side of body of smallest fish in the 6.0-10.9 mm size class are peppered with small, evenly spaced brown spots. The eyes are black. There is a slight concentration of melanophores on the dorsal surface of the swim bladder. Mid-laterally, small spots and dashes

form a series from above the swim bladder to the caudal fin base. Serial spots occur on the myotomes, especially posterior to the anus. The most distinguishing pigmentary feature occurs as a diamond-shaped patch on the isthmus connected to a dark brown line of melanophores that extends to the anus (Fig. 5). Caudal and pectoral fins have a series of small spots on each side of rays, whilst the fin fold is barren.

As fish grow, pigmentation becomes more diffuse over the head and body. The ventral diamond-shaped pattern on the isthmus is usually absent at 10 mm. At 18 mm, fish exhibit 8 or 9 weakly developed vertical bands or blotches, which often appear only epaxially. On the dorsal surface, a thin, faint line exists from nape to dorsal fin origin. Ventral surface of head, gut, and intestine are almost barren of pigment. A group of melanophores surround the base of the anal fin, then form a single line from the anal fin insertion to the base of the caudal fin.

Table 4. Meristic data for *Fundulus diaphanus menona* (6.0 to 21.9 mm TL). Mean values and range are given (modal values in parentheses).

	SIZE CLASS		
	6.0-10.9 mm	11.0-15.9 mm	16.0-21.9 mm
	N = 19	N = 33	N = 19
MYOMERES			
Preanal	12.7 (12) 11-16	14.6 (15) 13-16	14.2 (15) 11-15
Postanal	20.8 (22) 18-23	17.3 (17) 16-19	17.6 (17) 16-21
FIN RAYS			
Dorsal	7.3 (8) 4-9	9.2 (9) 8-11	9.6 (10) 8-10
Anal	7.7 (8) 6-9	8.5 (8) 8-10	8.9 (9) 8-10
Pectoral	10.1 (12) 5-14	11.8 (13) 8-15	12.9 (13) 11-15
Pelvic		4.7 (5) 3-6	5.4 (6) 3-6
Caudal	11.2 (10) 9-15	15.1 (15) 14-16	15.4 (16) 14-16

Largest fish in the 15.9 to 20.9 mm size class are darker than smaller fish, yet pigmentation remains uniform, except for vertical bands, which increase in size and intensity on the dorso-lateral aspect of the body (Fig. 5). The chin, premaxillaries, interorbit, and occiput also express increased pigmentation. The throat, gut and intestine are usually devoid of pigment, whereas the line of melanophores between anal fin insertion and caudal fin base is darker than in earlier developmental stages.

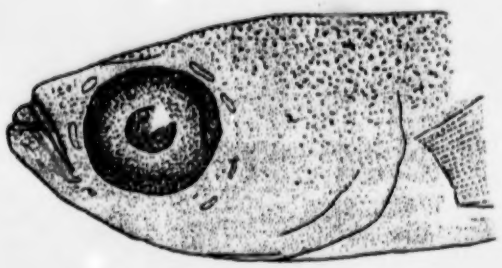

Fig. 6. Lateral view of head of the western banded killifish.

Brief description of adult *F. d. diaphanus*

Adult eastern banded killifish (66-84 mm TL) collected in Lake Memphramagog, Quebec have 10 anal, 10-11 dorsal, 16 caudal, 16-17 pectoral, and 6 pelvic rays. Preanal and predorsal lengths are 51% and 49% TL, respectively. Snout length is 30-35% of head length. The pectoral fin is situated relatively high on the body: its dorsal base follows an imaginary horizontal line from the lower margin of the orbit. The eye is situated in the upper half of the flattened head. Dorsal and anal fins are located midway, with the origin of the dorsal slightly preceding the origin of the anal fin. Anterior scales (cycloid) tend to be somewhat crowded and distributed unevenly on the dorso-lateral aspect. Between the head and dorsal fin origin, scale width is three times its length. On the caudal peduncle, scale width is twice its length. The caudal fin is rounded. Dorsal body scales are darkly outlined with minute spots whereas ventral scales are lightly outlined with marginal spots. Inter- and postorbital areas have dark brown subsurface features that appear vermiculated. The lower half of the head, gular region, and gut

appear barren. Approximately 15 thin, vertical bars are spaced more or less equally on the body from the pectoral fin to the caudal peduncle.

Table 5. Morphometric and meristic characteristics for banded killifish (this, and other studies). Range of values given in parentheses, with sources of data. *F. "diaphanus"* pertains to combined data on east and west subspecies.

	Fundulus d. menona	***Fundulus "diaphanus"***	***Fundulus d. diaphanus***
Characteristic			
Fin rays			
Dorsal	10 (8-10)a; 13b; 11 to 13 (10-14)c	13 (12-15)d	10 (8-10)a*; 13 or 14 (12-15)c; 14 (13-14)e**
Anal	9 (8-10)a; 11b; 10 or 11 (9-12)c	10-13d	9 (8-10)a*; 11 or 12 (10-13)b; 12 (11-12)e**
Pectoral	13 (11-15)a; 14 or 15 (13-17)b	16 (14-19)d	13 (11-15)a*; 16 or 17 (15-19)c; 13 (12-15)e**
Pelvic	6 (5-6)a	6d	6 (3-6)a*; 6 (4-6)e**
Caudal	15 (14-16)a	16 (14-17)d	16 (14-16)a*
Scales, lateral	49 (46-51)a; 43-45b; 40-44 (35-49)c	43-49d	46-48a; 45-49 (40-55)c

a)this study; b)Eddy and Surber (1960); c)Hubbs and Lagler (1964); d)Scott and Crossman (1973); e)Jones and Tabery (1980); *a)16-22 mm size class; **e)16-20 mm size class.

DISCUSSION

Descriptions of early developmental stages of the blackstripe topminnow have not been published and comparative morphometric data for fish >20 mm are available only for two features: preanal and head length relative to total length. Values for these characters in Ontario fish are similar to those reported in Jude (1982), whereas meristic information differs in at least three aspects (Table 5). Mean dorsal and anal fin ray counts for Ontario fish (8 and 10, respectively) are lower than for fish from Lake Michigan and Lake Erie drainage (9 and 12, respectively). Gruchy et al. (1973) counted 8 or 9 dorsal fin rays on fish collected in the Sydenham drainage, and Trautman (1981) reported 7 to 9 dorsal rays on Ohio fish. Caudal fin rays for Ontario fish average 15, compared with 14 rays in fish collected in bordering American states. We attribute differences in meristic data to differences in methods used by researchers to enumerate the final, posterior fin rays.

In the Great Lakes basin, age 0 cyprinodontids resemble only a few fish species, such as the bluntnose minnow, blacknose shiner *Notropis heterolepis*, blackchin shiner *Notropis heterodon*, and central mudminnow *Umbra limi*. Descriptions of immature stages of the blacknose shiner and the blackchin shiner have not been published, although the parataxonomy of both species has recently been studied (Timmins, unpubl. data 2000). Morphology and pigmentation are similar for killifishes and the cyprinids mentioned above, but the latter have a higher number of preanal myomeres (Fuiman 1983) and a homocercal caudal fin. The central mudminnow is terete, has a rounded caudal fin, fin ray complement similar to killifishes (Leslie and Timmins 1997), the premaxillaries are not protracted, and it has a higher number of preanal myomeres than killifishes.

The blackstripe topminnow is considered "vulnerable" in Canada because environmental conditions confine its distribution to a small area in south-western Ontario. Due to an affinity for turbid water, the blackstripe topminnow may be considered a "turbidafin. As such, it has availed itself of habitat mediated by human interference, which tends to increase the sediment load. Therefore, land use practices that improve water clarity or change other habitat variables throughout its present geographic range will threaten this fish. Trautman (1981) noted decline in numbers of blackstripe topminnows as turbidity increased and submersed bank vegetation became sparse in streams of northern Ohio. Thus, controlling factors determining its

reproductive activities and residence appear to bear mainly on the character and size of suspended sediments, and the type and amount of submersed bank vegetation and associated food.

The absence of blackstripe topminnow larvae in Whitebread ditch may accrue from inefficient sampling, or our inability to find them because of their differential seasonal and diel shifts in habitat use during early ontogeny. Most likely, reproduction did not occur at our sampling site. Agricultural ditches in the St. Clair flatlands are very similar in structure and water quality, i.e., enriched and highly turbid during late spring to mid-autumn, with edge vegetation consisting mostly of sparse, patchy grasses (Leslie and Timmins 1998). As we found no evidence of blackstripe topminnow reproduction in drainage ditches, and our catch per sampling effort was small, this type of habitat is probably marginal for the species. In contrast, tributary streams in the Sydenham drainage provide fish a relatively wide variety of cover and spawning substrate, as well as latitude for movement in response to changes in water clarity. Complete taxonomic separation of early developmental stages of killifishes awaits information on natural reproduction in the field and description of the blackstripe topminnow.

Banded killifish larvae have been described and illustrated by Fish (1932), whose specimens were "wild" western banded killifish, and Jones and Tabery (1980), whose fish were laboratory-reared eastern banded killifish. The two killifish species in Ontario are distinguishable according to lateral pigmentation and relative position of dorsal and anal fins. However, taxonomic separation of banded killifish subspecies is possible in respect of slight differences in modal values of myomere and fin ray counts, as well as developmental events in early life. These characteristics themselves vary between studies. For example, Fish (1932) counted 10 preanal and 22 postanal myomeres in 7.1-mm fish in the western subspecies, whereas in 8.0-mm fish, our counts were 13 and 21, respectively. Jones and Tabery (1980) recorded 11 and 24 myomeres in 7.9-mm fish of the eastern banded killifish. At 6 mm, Ontario killifish have incipient rays in median fins, and pelvic buds first appear at 10-11 mm. Yet, both of these developments occur in eastern banded killifish at 12-15 mm (Jones and Tabery 1980). We concur with Fish's (1932) observation of absorbed fin fold at about 13 mm, while scalation is initiated at 14-16 mm, or slightly earlier than Jones and Tabery noted in eastern banded killifish (16-17 mm). Finally, rays on all fins on eastern banded killifish are complete at 16-20 mm, whereas the full complement of rays on the western subspecies occurs at about 13-15 mm. Apparently, onset and completion of several developmental events during early ontogeny in the western subspecies precede those in the eastern subspecies.

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